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merely a psycho-physiological one, but that the theoretical question as to the manner in which the phenomena of the external world become presentations in consciousness also is involved. This opportunity for emphasizing one factor or the other is the reason for the various methods of approach and the different answers given by investigators. Ophthalmologists, attacking the problem from an anatomical-physiological point of view, established such laws as those of Donders and Listing. The search for some general principle led inquiry in a physiological-mechanical direction and to Wundt's principle of simplest innervation. Helmholtz thought that the really deciding factor in the problem is to be looked for in an optical principle and encouraged research which proceeded from the psychological conception involved in Meissner's principle of orientation. Earlier investigators, however, erred in attempting to establish a law or principle of eye-movements, rather than to inquire into their import for visual perception. Only by focusing on this, and by specializing research in connection with reading, has a definite and clear answer become possible. The fact, established by Erdmann and Dodge, that visual recognition takes place exclusively during the pauses of rest, while the eye-movements, properly speaking, are interfixation movements, represents a psycho-physiological solution of the problem. It was reached by ascertaining the time necessary for single ocular movements. Volkmann, Huey, Lamanski, Dodge and Cline experimented with this point in view. Dearborn, however, who perfected the method of photographic registration, was able to show that the average time of a single movement is probably 0.02 sec. or somewhat less. This brief duration, in view of Plateau's results, naturally precludes the possibility of our distinguishing between black letters and white spaces while the eye moves.

Since the question of the function of eye-movements in reading is but a specialization of the more general problem of their function in visual perception throughout, we can almost reverse the commonly accepted theory of the past and now say: Seeing, while the eye moves, is scarcely of importance for visual recognition; whenever we really visually recognize, the eye usually is at rest. (Obviously a guarded statement which implies the belief that the last word in the matter has not as yet been spoken.)

M. W. MEYERHARDT.

An Experimental Study of Visual Fixation. PROF. RAYMOND DODGE. Studies from the Psychological Laboratory of Wesleyan University, Vol. I, No. 1. Issued by the Psychological Review, as Monograph Supplement of November, 1907.

Prof. Dodge first observed the movements of the eyes during supposed fixation, with the movements of head and body to which these eye-movements are in part compensatory. The eye-movements, however, are found to be due in part to *irregular* movements of head and body, and are then disturbances of fixation for which there can be no compensation. The pulse and breathing are important factors in producing the fixation movements. Head movements may be demonstrated by watching the reflection of objects from behind as seen through smoked glasses upon cross-section paper. Satisfactory methods of recording the movements have not been worked out. The compensatory eye-movements are united with the movements of head and body "into a thoroughly organized motor system," furnishing a co-ordinating mechanism "capable of explaining the intimate correspondence between *tactual* and *visual space*." There are also visual motives for the fixation movements, in *retinal fatigue* and in the correction of inadequate binocular co-ordination.

Control of fixation movements involves ocular reactions, and these

are again found to be slow, but a minimum of 1300 was reached. The method of taking the reaction times and making the exposures was that of Prof. Holt, with the alternating arc light, the stimulus being given by the fall of a screen which simultaneously threw the actinic beam upon the cornea, to be reflected to the falling plate of the camera. The alternations of the current gave an approximately accurate time-record in a series of dots, and this might be made fully accurate by interrupting the direct current with a tuning fork. The arc light was "stopped down" to comfort, by plates of pot blue glass, without materially lessening the effect upon the plate.

Repeated fixations of the same word gave very different locations of the point of regard, but all are "perfect fixations" when the "object of interest is brought to a retinal area of clear vision," the functional centre of the retina varying in size with circumstances.

Prof. Dodge calls a fixation "adequate" when it is long enough and accurate enough to condition a "clearing-up" of the perception of the object of regard. He measured the time needed for the clearing-up of words exposed on various pre- and post-exposure fields such as may occur in reading, and concludes that "the shortest adequate fixation pauses in reading are between 70 σ and 100 σ ." But words exposed peripherally, in reading for example, may modify the total consciousness without clearing up, and he investigated the effects of such factors, finding the movement to be from general to special effects, phrase, sentence, and paragraph, episode and plot forming a "dynamic background" for each new word-complex as it clears up.

The article contains a reproduction of a photographic record of the eye-movements in fast reading, taken with the alternating current. The "overshoots" of the eye, shown in the reviewer's records, are confirmed but not yet explained. The shortest fixation pause occupied 40 σ .

Prof. Dodge thinks that to explain the apperception processes which condition reading we must look at the "concurrent complication of psychological processes of perception extending through several fixations." To study these he used the exposure apparatus previously described, and measured the effects of pre-fixational perception of peripherally placed words. It is unfortunate that the author does not state the distance of these stimuli from the eye, so that the peripheral angle might be known, but the effects are evident and are such as are to be expected.

Prof. Dodge fails to find experimental evidence for the traditional theory of retinal local signs, and raises the question whether the spatial relations of the total visual field are determined by its relations to the fovea, or whether the object of regard is not rather "determined in its spatial relations by its apparent position in the total visual field." He proposes a substitute theory of "genetic organization of the retinal elements" which is hardly capable of brief statement and criticism.

The appendix to the article contains a timely review of the methods and technique of recording eye-movements by photographic registration, and describes the Wesleyan apparatus.

Professor Dodge has in some way fallen into an unfortunate error as to the size of the foveal and macular fields of regard, stating these as less than one-fifth their actual size as calculated by the present writer upon the data given by Helmholtz and Köllicker. This mistaken notion of the relative sizes of the central and peripheral fields has evidently intensified somewhat the zeal of the author in some of his contentions. But the present writer's own experiments upon the effect of peripherally given stimuli corroborate Prof. Dodge's

conclusions as to the large part played by extra-foveal if not extra-macular vision, in reading at least; and probably the error has not invalidated the main contentions of the article, whose positive contribution is important, and whose author continues to show his clever originality in experiment.

EDMUND B. HUEY.

Das Behalten und Vergessen bei Kindern und Erwachsenen nach experimentellen Untersuchungen, von PAUL R. RADOSSAWIJEWITSCH. Bd. 1, Otto Nemnich, Leipzig, 1907. pp. 197. (Pädagogische Monographien hrsg. von E. Meumann.)

The author was a pupil of Meumann under whose direction this work was done. After giving an historical account of previous work in this field, the writer proceeds to experiments of his own; first on adults and then upon children. He finds that memory is more persistent for meaningless material than for that which has a meaning. The number of repetitions necessary both to learn and to relearn diminish with time, but the growth of practice is far greater in learning than in relearning. Even associations improve by practice as does the certainty of reproduction, provided the fidelity of the first impression remains constant. Learning and retaining are two very distinct processes of memory and have their own laws and conditions. The learning of meaningless material is of course far harder. A special practice in memory improves memory in general. As to forgetfulness, it begins very rapidly after learning and then its curve sinks more slowly. The initial loss is not nearly so rapid as Ebbinghaus thought. The types of memory differ greatly, although this seems to depend partly upon practice. The last and the first syllables of a series are least and those in the middle most forgotten. There are distinct slow and fast types of learning, although the former may by practice approach to some extent the latter, so the difference may be due to practice. Those who learn slowly retain better. It was a great help to each to follow his own type of memory with which few seem to be acquainted. All persons experimented upon were of mixed type, chiefly either visual-acoustic or acoustic-visual. Next came motor-acoustic and acoustic-motor. There was no visual-motor or motor-visual. The longer and harder task was given memory, the more sense elements were used, and only in very short series of syllables was there anything like a pure type. The impulse toward the sense of what was learned repressed the mere sensuous material. Nearly all, at first, tried to devise some logical connection between syllables; but with more practice, the more mechanical became the process. All are inclined to use rhythm and tempo, trying many at first and focusing later to a few. There was no indication that people of different nationalities preferred special rhythms. Adults exceeded children only when the work was prolonged, but adults need less repetitions. Neither showed any pure concept types.

The Influence of Bodily Posture on Mental Activities, by ELMER ELLSWORTH JONES. Columbia Contributions to Philosophy and Psychology, Vol. XVI, No. 2. New York, The Science Press, October, 1907. pp. 60.

From the results of various tests in many series, the author found that the following activities were best performed in the vertical position. They are . . . the discrimination of pitch and number of taps per minute, the strength of grip. The following were best performed lying down . . . tactile discrimination, visual and auditory memory tested both by rapidity and fewness of errors and adding. The subjects showed greater signs of fatigue in the horizontal than in the vertical position.